The Next Environmental Battleground: Indoor Air

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Executive Summary

In the workplace, Americans are exposed to hundreds of airborne toxic chemicals every day. Carpets, furniture and walls emit small quantities of the carcinogen formaldehyde. Laser printers and copiers emit ozone. And almost anything in the outdoor air may be brought indoors.

Many of the chemicals in the air where we work are also in the air of our homes. And most employees probably bring toxic chemicals with them to the workplace each day:

- Clothes that have been dry-cleaned emit the carcinogen perchloroethylene.
- The glue used to "stitch" many articles of clothing emits formaldehyde.
- Ordinary shoe polish may emit the carcinogen methylene chloride.

Are we at great risk? Probably not. Human beings have always been exposed to carcinogens that occur naturally in the air we breathe and the food we eat. If small quantities of carcinogens could kill us, the human race would have been extinct long ago.

However, there are problems. Poorly ventilated buildings have harbored Legionnaires' disease and tuberculosis. Largely because of federal policy, some excessively insulated buildings have become "sick" — leading to increased absenteeism and lower productivity.

What should be done? The private sector is already responding, largely for economic reasons, to improve employee productivity and to avoid lawsuits:

- Most indoor air problems are caused by poor ventilation, and building owners are discovering that improving ventilation is often profitable.
- Spurred by the incentives of the marketplace, inventors are finding new and cheaper ways to clean the air.
- Boston ferns and other plants have proved to be remarkably capable of removing toxic chemicals from indoor air.

Should more be done? Many propose that the federal government regulate indoor air the way it regulates outdoor air. But that cure could be far worse than the disease. For example:

- The outdoor air toxics regulations of the new Clean Air Act require that the private sector spend $6.5 billion for every life hypothetically saved.
- In one case, the Environmental Protection Agency (EPA) imposed a rule that would require $5.7 trillion per life hypothetically saved — which implies that the EPA is willing to spend the entire GNP to save a single life.

Applying comparable regulations to indoor air would devastate the real estate industry, which already is depressed. It also would harm workers. For example:

- If government required $100 billion of spending to improve indoor air quality, that would be equivalent to a $900-a-year tax on every American worker.
- The cost would equal 10 percent of the income of a minimum-wage worker but less than 1 percent of a $100,000-a-year worker.
- Such a regulatory burden also would eliminate more than one million, mainly low-income, jobs.

The proponents of indoor air regulation seek to protect workers' health and safety. However, since there is a relationship between low income and mortality, high regulatory costs may actually increase death rates. Further, the death rate increase may be most pronounced among workers with the lowest incomes. Studies suggest that:

- If indoor air regulations reduce the income of workers by $10 billion per year, the result could be 1,927 additional deaths.
- The burden would not be spread equally. The increased probability of death would be 218 times greater for an $8,000-a-year worker than for a $60,000-a-year worker.

According to the National Cancer Institute, poverty is one of the most important causes of cancer. Thus, any effort to eliminate carcinogens in the workplace by imposing regulations that lower employee incomes could cost more lives than it saves.

If government does become more involved, some solutions are better than others. Certification (providing information to employees and customers) would be the best approach. Under ordinary circumstances, people would assume that a building met an industry-developed ventilation standard and was periodically checked to ensure that no major contaminant was in the ventilation system. The owner of any building that failed to meet the prescribed air quality standards would be required to post a notice to that effect.

The second-best approach would be to require that all buildings meet a standard but allow building owners to find the least costly way of meeting that standard (e.g., by opening windows, planting Boston ferns, improving the ventilation system, etc.). Under this approach, government would set the standard and the marketplace would determine how to meet it.

The worst approach would be government regulation of the sources of indoor air pollution — asserting control over everything from carpets to workers' clothing. This approach, comparable to the approach now used to regulate outdoor air, would likely cost money, jobs and lives — while bringing about little improvement in the quality of our air.

Introduction

Every day, Americans are exposed to thousands of chemicals. In a typical workplace, people are exposed to chemicals emitted from the carpet on the floor, the paint on the wall, the building materials in the ceiling, and even from the chair they sit on and the desk they use.[1]

The air in an ordinary office contains trace amounts of an entire laundry list of toxins and carcinogens. The chemicals that compose many common products break down slowly and seep imperceptibly into the air. For example:

- Formaldehyde, which is known to cause cancer in rats at high dosage levels, is emitted from the glues used in walls, furniture and carpets.
- Ozone is emitted from laser printers and copiers.
- Benzene, another carcinogen, may seep in from a connecting garage, and any chemical present in the outdoor air may be brought indoors as air is ventilated.

Employees also contribute toxic chemicals to the indoor air:

- Clothes that have been dry-cleaned emit the carcinogen perchloroethylene.
- The glue used to "stitch" many articles of clothing emits formaldehyde.
- Ordinary shoe polish may emit the carcinogen methylene chloride.

"The carcinogen methylene chloride is present in about one-third of common household products."

A great many of the chemicals present in the air at work are also in our homes. In addition to the chemicals in carpets, furniture, upholstery and dry-cleaned clothes, moth balls and air fresheners typically emit the carcinogen paradichlorobenzene, and most paint removers and spray paints probably emit methylene chloride. In fact, a study by the Environmental Protection Agency (EPA) found that methylene chloride is present in about one-third of 1,000 common household products.[2]

In large quantities, any of these chemicals could be dangerous. But are they dangerous in the small amounts to which the average American is exposed? Probably not. Most toxic chemicals in the air are measured in parts per million or parts per billion. Without sophisticated technology, we could not even detect them. Moreover, thousands of other carcinogens and toxic chemicals occur naturally in our food.[3] If exposure to small amounts of dangerous chemicals could kill us, the human race would not have survived.

Nonetheless, because there are serious air quality problems in some buildings and homes, many people are advocating that the federal government aggressively regulate indoor air.

Should the Federal Government Regulate Indoor Air?

"Some airborne toxins are more than 100 times more concentrated indoors than outdoors."

Currently, the EPA regulates outdoor air but has little authority over indoor air. The Occupational Safety and Health Administration (OSHA) has the authority to regulate air quality in the workplace, but it has not imposed the stringent standards the EPA has applied outdoors. No federal agency currently has the power to regulate the air quality inside a person's home.

The Argument for Regulation. The strongest argument in favor of aggressive regulation is that whatever justifies the regulation of outdoor air would appear to apply with much greater force to indoor air. For one thing, most people spend far more time indoors than out:[4]

- It has been estimated that employed men in the U.S. spend, on the average, about 90 to 95 percent of their lives indoors.
- These men presumably breathe from 10 to 20 times as much indoor air as outdoor air.

For another thing, hazardous pollutants are typically many times more concentrated indoors. According to a five-year study by the EPA:[5]

- More than 500 different organic compounds, many of them known carcinogens, were found in the buildings studied.
- Some of the compounds were over 100 times more concentrated indoors than outdoors.

The Argument Against Regulation. The strongest argument against giving an agency such as the EPA the authority to regulate indoor air is that it would be like giving a machine gun to a child. The EPA has imposed huge costs on the private sector to eliminate trivial risks and make infinitesimal improvements in the health and safety of Americans. If a federal agency were to apply comparable standards to indoor air, the effect on the economy would be worse than the Great Depression.

Take formaldehyde, for example. Although there is no evidence that breathing small amounts of the chemical causes cancer in humans, very large doses do cause cancers in rodents. Table I shows how the risk of breathing

formaldehyde compares with other human risks, based on the assumption that human risks are just like rodent risks, adjusted for body weight. The table shows that for the average person:

- There is no more reason to be concerned about breathing formaldehyde in the workplace than there is to be concerned about drinking two Cokes a day or a glass of wine with dinner.

- Furthermore, the (formaldehyde) risk of breathing air at work for a day is no greater than the risk of breathing air at home 14 hours a day for 9-1/2 days or 24 hours a day for 5-1/2 days.

"If the EPA applied outdoor standards to indoor air, it could shut down every home and office building in the country."

But suppose the EPA applied the same standards to formaldehyde in businesses and homes that it has applied to other chemicals. Conceivably, it could rule that every office building and home is unfit for human habitation:[6]

- In the 1980s, the EPA closed down 35 wells in California because the water contained traces of a carcinogen.

- Yet based on rodent experiments, the risk of breathing formaldehyde at work is 1,450 times greater than the risk of drinking water from the worst California well.

- If the EPA was justified in shutting down California wells, it would seem to be over a thousand times more justified in closing down every building in the country.

Another way to appreciate the potential dangers of allowing the EPA to regulate indoor air is to consider the agency's pesticide regulations:[7]

- The EPA has forced the agricultural sector to bear millions of dollars in costs in an effort to reduce carcinogenic pesticide residues in food.

- Yet based on rodent experiments, the (formaldehyde) risk from breathing air for one day at work is 11,600 times greater than the daily risk of consuming pesticides in food.

- If eliminating pesticides from food is a reasonable goal, closing down all of the nation's office buildings would appear to be almost 12,000 times more reasonable.

The EPA's use and misuse of rodent experiments and its resistance to sensible cost-benefit analysis are considered below.

"There is no greater risk from breathing formaldehyde in the workplace than from drinking two Cokes a day or a glass of wine with dinner."

TABLE I

Equal Risks of Getting Cancer[1]

(Based on rodent experiments)

Source	Carcinogen
Breathing air at work — 1 day	**Formaldehyde**
Wine — 1-1/4 glass	**Ethyl Alcohol**
Beer — 2 glasses	**Ethyl Alcohol**
Cola — 2 cans	**Formaldehyde**
Bread — 1 loaf[2]	**Formaldehyde**
Breathing air at home — 9-1/2 days[3]	**Formaldehyde**

Note: The items listed above are for illustrative purposes only and are not intended as a guide for safe behavior. Relative risk is based on experiments subjecting rodents to very high dosages. The risk of these items to humans, in the quantities given above, is thought to be trivial.

[1]The underlying measure of risk used here is a HERP value: Human Exposure dose divided by Rodent Potency dose. The measure of rodent potency is the milligrams of substance per kilogram of rodent body weight necessary to produce cancer in half of the rodents, given daily exposure over the rodents' lifetime. Human exposure is measured by the daily consumption indicated in the table per kilogram of human body weight. In the table above, the HERP values have been normalized with respect to the HERP value for the daily U.S. average exposure to formaldehyde from breathing air at work.

[2]30 slices.

[3]14 hours per day.

Source: Based on data taken from Bruce N. Ames, Renae Magae, Lois Swirsky Gold, "Ranking Possible Carcinogenic Hazards," *Science,* Vol. 236, April 17, 1987, pp. 271-280.

Real Problem: Building-Related Illness. While most people, most of the time, have little to fear from pollutants in their work environments, a few real problems have been identified.[8] A building-related illness (BRI) is said to exist when a particular pollutant causes a specific illness. The most infamous example was the Legionnaires' disease that killed 29 people during an American Legion convention in Philadelphia in 1976. The disease was caused by bacteria transmitted through an air-conditioning system. More recently, Legionnaires' disease killed or injured workers in government buildings in Richmond, California, and Ogden, Utah. There have also been cases of tuberculosis and other airborne infections whose spread was facilitated by poor ventilation systems.

Real Problem: Sick Building Syndrome. BRI is relatively rare. A more common problem is the sick building syndrome (SBS) characterized by general complaints such as headaches, fatigue, nausea, eye, nose and throat irritation, coughs and muscle pain. These symptoms are thought to be caused by a combination of airborne substances. [See Table II.] Overall:

- The World Health Organization estimates that up to 30 percent of new or renovated energy-efficient buildings may suffer from sick building syndrome.[9]

- The EPA estimates that sick buildings cost the U.S. economy $60 billion a year in medical expenses, absenteeism, lost revenue, reduced productivity and property damage.[10]

While these estimates may be exaggerations, there *are* sick buildings, and a number of lawsuits claiming SBS illnesses have been filed and won.

How Government Has Contributed to the Problem. Many sick buildings are partly the result of federal government policy.[11] In response to the energy crisis in the 1970s, the federal government introduced subsidies and mandates to encourage the construction of energy-efficient buildings.

"Sick buildings cause lower productivity and yield lower rents for building owners."

TABLE II

Percentage of Buildings in Which A Pollutant is a Problem

Allergenic Fungi	**31%**
Dust Particles	**29%**
Low Humidity	**26%**
Allergenic or Pathogenic Bacteria	**8%**
Formaldehyde	**7%**
Vehicle Exhaust Gases	**6%**
Volatile Organic Compounds	**3%**
Tobacco Smoke	**3%**
Fibrous Particles	**2%**
Ozone	**1%**

Source: Gray Robertson, "Indoor Air Pollution: Sources, Effects and Mitigation Strategies," in Donald J. Ecobichon and Joseph M. Su, eds., *Environmental Tobacco Smoke: Proceedings of the International Symposium at McGill University* (Lexington, MA: Lexington Books, 1990), p. 339.

These over-insulated structures, which have thick walls, low ceilings, sealed windows and poor ventilation systems, tend to trap chemical fumes that otherwise would disperse. The effect is intensified because in such buildings indoor air is recirculated more often than in conventional buildings. *The construction of excessively insulated buildings is still encouraged by government regulations, even though energy prices are now lower in real terms than they were in the early 1970s.*

How the Federal Government Manages Its Own Buildings. Before giving government more power over indoor air in the private sector, we should ask how well the federal government has managed its own indoor air.

- In 1991, eight employees of the EPA filed a multimillion-dollar lawsuit against the agency, alleging that the air quality in the EPA's Washington, DC, headquarters was making them ill.[12]

- An outbreak of Legionnaires' disease at the Social Security Administration's office in Richmond, California, produced ten victims, including one death, and led to a $9.5 million lawsuit.[13]

- Another outbreak of Legionnaires' disease hospitalized a worker at an Internal Revenue Service (IRS) building in Ogden, Utah.[14]

"The EPA's own building is apparently a 'sick building'."

State and local governments are also culprits. An extraordinary number of sick building investigations and lawsuits involve municipal offices, schools, courthouses, etc. For example, a 1991 addition to the sick building list was the structure occupied by a New Jersey pollution control agency.[15] Indeed, one reason why so many government buildings are sick may be that government is insulated from the normal pressures of the marketplace. [See the discussion below.]

Solving Problems Without Regulation

Before enacting more laws and regulations, politicians would do well to consider how the private sector is responding to issues of indoor air quality. The following is a brief summary.

Individual Choice. Individual preferences differ. The willingness of different people to pay for higher quality also differs. Higher quality air is often (although not always) more expensive, and avoiding lower quality air usually involves a cost — if only in terms of inconvenience. One way of satisfying different preferences is to let people make their own choices.

Most of us voluntarily accept less-than-perfect indoor air quality — at work and away from it. As noted above, the air quality in most homes is far from perfect, and few of us would be willing to spend the money or suffer the inconvenience required to achieve perfection. We also voluntarily accept less-than-perfect air in other places. International air travelers often experience discomfort from air that is recirculated during long flights. Presumably the cost of this discomfort is outweighed by the advantages of air travel.

People also choose to accept less-than-perfect air quality when they choose professions and employers. Those who are strongly averse to prolonged exposure to recirculated air presumably choose not to be astronauts, airline pilots or deep-sea divers. Those who are strongly averse to polluted air presumably choose not to be coal miners or lumber mill workers. On the other hand, those whose tolerances are higher often earn more for working in less pleasant environments.

"The private sector already has financial incentives to provide clean air."

Market Incentives. There are obvious limits to individual choice. Whether in airplanes or office buildings, everyone's ideal cannot be met. Airplane manufacturers and building developers must make trade-offs between air quality and cost. The marketplace gives them strong incentives, however, to satisfy most of their customers most of the time. Building owners, even if they never enter their buildings, find that buildings, with poor indoor air quality are less valuable and produce less rental income.

Consider that the typical absentee rate for office workers is less than 5 percent.[16]

- If because of indoor air pollution the absentee rate increases from 5 percent to 7.5 percent, which is not uncommon in sick buildings, the building owner's expected loss will be $3 to $5 per square foot of floor space per year.[17]

- The present value of $5 per year, assuming a discount rate of 5 percent, is $100 — which rivals the construction cost per square foot for many buildings.

- Thus building owners have strong economic incentives to correct the most serious problems and improve indoor air quality.

Using the Courts. One of the most common problems of indoor air quality occurs when people become ill not because they have voluntarily accepted imperfect indoor air quality but because the quality deteriorated due to someone's negligence. The building-related illnesses described above are examples.

The tort law, however, gives victims recourse.[18] Indeed, one of the fastest-growing areas of tort law is indoor air lawsuits — which have even named architects and interior designers as defendants. Fear of lawsuits is a motive for maintaining high-quality indoor air, and the majority of building managers are well aware of the potential threat.

Private Sector Solution: Open the Window. In most cases of unacceptable indoor air quality, the best solution is to improve building ventilation.[19] For example:

- In a study of more than 200 sick buildings, the National Institute for Occupational Safety and Health (NIOSH) found that inadequate ventilation was the primary problem in 48.3 percent.[20] [See Figure I.]

- Another NIOSH study found that, from 1978 to 1988, 53 percent of the complaints in 532 buildings were attributable to inadequate ventilation.[21]

Of course, even in those cases where poor ventilation is the primary problem, the appropriate solution varies. But improving ventilation is part of almost all cost-effective solutions.

The importance of proper ventilation was acknowledged in a U.S. General Accounting Office (GAO) report that stated, "Correcting ventilation problems ... can reduce indoor air pollution problems more quickly and extensively than trying to identify and control individual indoor air pollutants."[22] Some specialists say that the problems in approximately 80 percent of all sick buildings can be eliminated by simply improving existing ventilation systems. And according to a recent study, quadrupling the minimum ventilation rate[23] would cost less than 5 percent of the average energy operating costs in a typical building.[24]

"Most indoor air problems can be eliminated with proper ventilation."

Private Sector Solution: Grow Plants. A surprising finding of recent research is that many plants are capable of removing pollutants from indoor air. According to Dr. Ray Walverton, a former researcher for the National Aeronautics and Space Administration (NASA):[25]

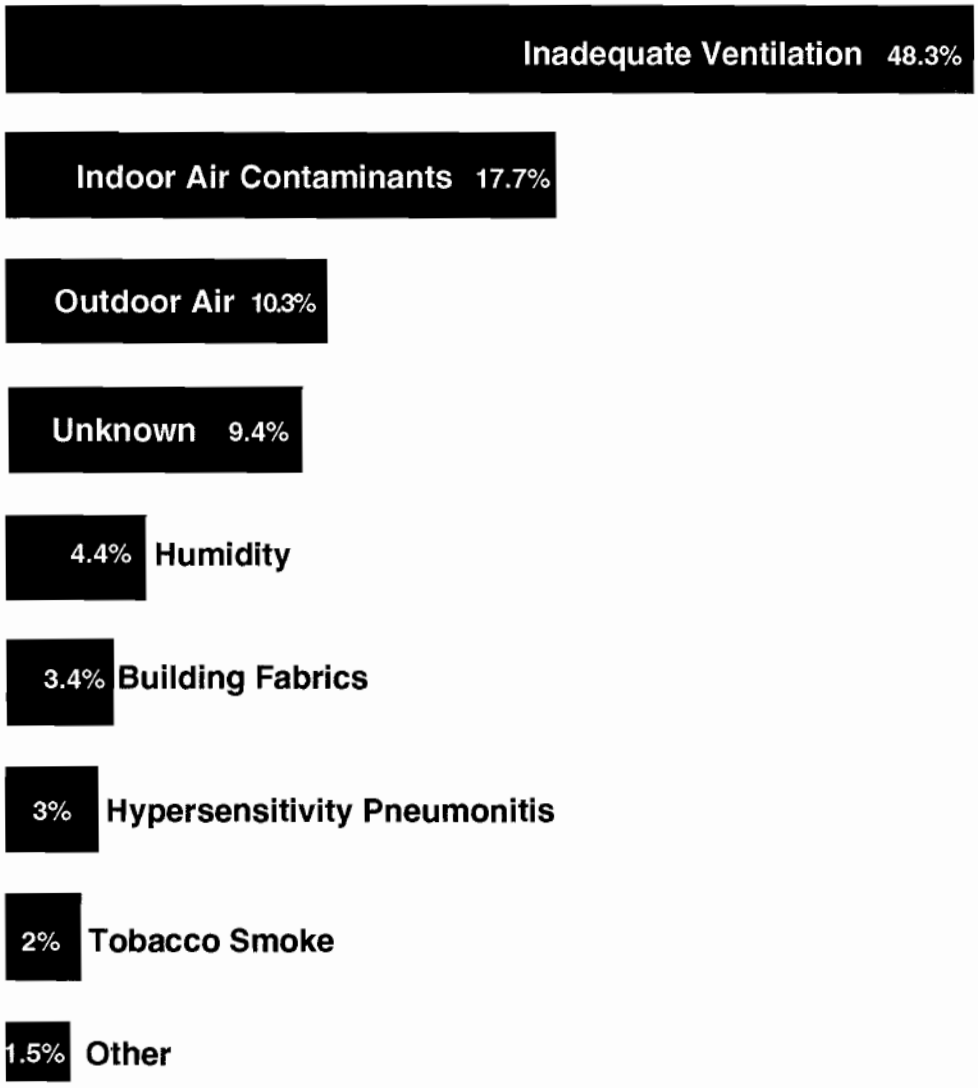
- For every 100 square feet of office area, one or two Boston ferns can clean so much formaldehyde out of the air that it is no longer detectable.

- Other toxin-eating plants include the azalea, poinsettia, dieffenbachia, gerbera daisy, corn plant, pot mum, Chinese evergreen and various species of philodendron, schefflera, chrysanthemum, tulip orchid and ligustrum.

"A couple of Boston ferns will remove the formaldehyde from a 100-square-foot office."

FIGURE I

Suspected Causes of Building-Associated Illness



Source: E. J. Bardana, Jr., A. Montanaro and M. T. O'Hollaren, "Building-Related Illness: A Review of Available Scientific Data," *Clinical Reviews in Allergy*, Vol. 6, 1988, Table 4, p. 78.

So far, studies have shown that plants can remove from the air three carcinogens: formaldehyde, benzene and trichloroethylene. It is likely that they can remove many other toxins as well. Interestingly, the finding that plants can absorb airborne toxins grew out of NASA research on ways to keep the air clean on long space flights. Similar findings are reported by former Soviet space scientists who now seek to market their knowledge as a cure for sick buildings in the West.[26]

Private Sector Solution: New Technology. If government regulation of indoor air followed typical regulatory practices, the regulators would tell building owners *how to manage* their air. An advantage of the marketplace is that anyone with a better idea is free to compete. In response to the growing recognition that poor air quality can be costly (in terms of low productivity, lawsuits, etc.), a thriving industry has developed — with a steady stream of new products and new ideas to solve the problem. Almost every issue of *Indoor Air Review, Pollution Equipment News, Environment* magazine and the *Journal of Environmental Health* contains advertisements for new products or notices of conferences and seminars on indoor air quality.

The Government's Record on Outdoor Air

"The EPA spends the most money on programs that are least likely to improve the environment."

According to the EPA, the United States spends $115 billion per year to clean up the environment, devoting a large part of that money to outdoor air. Environmental spending equals 2.3 percent of our Gross National Product (GNP), 40 percent of the defense budget and almost three times the amount spent on the environment by the entire European Community.[27] Are we getting our money's worth? The evidence suggests that we are not.

Misplaced Priorities. Most environmentalists, regardless of other differences, agree that the EPA has done a poor job:[28]

- In an internal study, EPA staffers were asked to rank the agency's programs in order of their environmental importance.
- When this ranking was compared to a ranking of EPA expenditures, priorities were found to be almost reversed.

The EPA spent the most on programs that were politically popular and very little on those that were more likely to advance environmental objectives. This finding was echoed in an outside review of the EPA by scholars at Harvard University.[29]

Mandating Methods Rather than Achieving Results. One way to achieve higher air quality is to set a limit on pollutants and allow industry to find the least-cost way of achieving the result. Another way is to tell industry *how* to control pollutants. The EPA usually chooses the latter method.[30] It relies on a highly centralized command-and-control approach that is susceptible to political manipulation, is unresponsive to local information and almost always results in higher costs.

Typically, the EPA responds to a pollution problem by requiring that all polluters install the same type of emission control equipment. For example, in attempting to reduce sulfur oxides emissions from coal-powered generating plants, the EPA has required that all new plants be constructed with expensive stack scrubbers, even though burning low sulfur coal is often a more effective and less expensive way of achieving the same goal. Indeed, when the EPA began implementing the stack scrubber policy in 1978, as required by the 1977 Clean Air Act amendments, they found that in some cases scrubbers actually increased the emissions of sulfur oxides.[31]

Telling producers *how to control* outdoor air pollutants can be extremely costly and ineffective. Several studies have attempted to determine the cost difference between the least-cost method and the EPA's approach.[32] As Table III shows:

- In almost all cases, EPA command-and-control regulations resulted in a higher cost of pollution control than the available alternatives.
- In one case, EPA regulations cost 22 times more than an alternative.

"EPA regulations cost as much as 22 times more than necessary."

TABLE III

Wastefulness In the Regulation of Outdoor Air

Study	Pollutant	Industry	Ratio of Mandated Cost to Least Cost
Atkinson-Lewis	Particulates	Power and other	6.0
Diemer-Eheart	Sulfur dioxide	Power	2.0
Hahn-Noll	Sulfates	Steel, petroleum, power	1.1
Krupnick	Nitrogen oxide	Steel, chemicals, oil (200 sources)	6.0
Maloney-Yandle	Hydrocarbon	DuPont Chemical	4.2
McGartland	Particulates	All sources (Baltimore)	4.2
Palmer et al.	CFC	Refrigeration (Plastics)	2.0
Roach et al.	Sulfur dioxide	Power	4.3
Seskin et al.	Nitrogen oxide	Power, steel, oil (Chicago)	14.4
Spofford	Sulfur dioxide	Power, steel, oil (Delaware Valley)	1.8
Spofford	Particulates	Power, steel, oil	22.0

Source: Tom Teitenburg, *Environmental and Natural Resource Economics,* 2nd ed. (Glenview, IL: Scott Foresman & Co., 1988), pp. 346-7, cited in Bruce Yandle,"Why Environmentalists Should be Efficiency Lovers," Publication No. 105, Center for the Study of American Business, Washington University, St. Louis, MO, April 1991.

Failure to Use Cost-Benefit Analysis. Quite apart from the question of how to achieve a result is the question of whether the result is worth achieving. The EPA often imposes millions of dollars of costs on industry and achieves negligible or unmeasurable results. Although the agency does its own cost-benefit calculations, such analysis is often ignored in its cost-is-no-object approach to pollution control. The EPA is not alone; OSHA and other federal agencies are guilty of similar regulatory sins.

Failure to Use Science. To scientists, the EPA is notorious for sometimes ignoring and other times misusing scientific studies to promote its own aims. The agency all too often uses such studies to advance a political agenda rather than to judge whether the agenda should be pursued. Among the well-publicized examples are EPA risk assessments in the 1980s that grossly exaggerated the dangers of radon, dioxin and asbestos. A special advisory panel of prominent scientists convened by the EPA to study the agency's programs published the following indictments:[33]

"The EPA's own study showed the agency routinely misuses science."

- "Scientists at all levels believe the EPA does not use their science effectively."
- "EPA science is perceived by many people, both inside and outside the agency, to be adjusted to fit policy."
- The "EPA often does not scientifically evaluate the impact of its regulations."
- "The interpretation and use of science is uneven and haphazard across programs and issues at the EPA."

Currently there are more than 9,000 EPA regulations, costing taxpayers and industry billions of dollars every year.[34] Yet many of these regulations are based on the poor quality of science about which the advisory panel complained.

Case Study: The EPA's War on Cancer.[35] About one in every three Americans will get cancer. About one in five will die from it. What should be done? An EPA executive has said that the most effective way to combat cancer would be to give the entire EPA budget to the National Cancer Institute.[36]

But that's not what the bureaucrats are doing. Despite the fact that industrial products and food additives cause less than 3 percent of all cancers,[37] the federal government is imposing billions of dollars of costs on the American public in its efforts to prevent exposure to trace amounts of environmental chemicals. The most common government standard is that a chemical should be outlawed if one person out of one million exposed over a lifetime

could theoretically get cancer from it. Even though 300,000 people out of one million will get cancer anyway, regulations cost the public billions to prevent one more theoretical case.

"The most effective way to combat cancer: Give the entire EPA budget to the National Cancer Institute."

Typical EPA methods for evaluating the public health risks from air pollution greatly overstate those risks. For example, the EPA calculates potential risks from exposure to an air pollutant by testing the chemical for toxicity in laboratory animals:

- The chemical is administered to rats and mice in massive daily doses just below the amount that would kill them immediately.
- At these high levels of exposure, one out of every two chemicals ever tested (both natural and man-made) eventually causes cancer in at least one species of rodent.
- The EPA then extrapolates from rodents to humans and estimates the human risk of cancer from exposure to the same chemical.

Scientists are increasingly skeptical about the value of such extrapolations. Many are also skeptical about what the EPA does next:

- To calculate the "risk" to human populations, the EPA postulates an imaginary "Most Exposed Individual" (MEI) who lives on the property line of the emissions source and breathes the highest level of emissions from that source for 70 years, 24 hours each day.
- The EPA then assumes that everyone is an MEI.
- Even with these pessimistic assumptions, the EPA estimates that only 1,700 to 2,700 cancers are caused each year by exposure to approximately 90 potentially hazardous air pollutants.
- While that hypothetical number may seem large, it is a small fraction of the almost one million cancer cases occurring each year in America.[38]

Even if the EPA's risk assessments were correct, the cost of preventing cancer through EPA regulations would be extremely high. Some estimate that the air toxins section of the amended Clean Air Act will cost from $20 billion to $30 billion — about 10 to 15 times the entire budget of the National Cancer Institute. But because the regulations target only the largest polluters, the maximum reduction in cancer cases is 350 to 500 per year. That represents a cost of between $40 million and $86 million per cancer avoided.[39]

The EPA's extreme risk models are notoriously faulty, however. A study of Allegheny County, Pennsylvania, the site of the largest concentration of industrial coke ovens in the country, concludes that the EPA's estimate of cancer caused by coke emissions is exaggerated by a multiple of 100:[40]

- By the EPA's calculations, its regulations on coke emissions cost $6.8 million per cancer prevented.
- Based on more realistic calculations, the cost is $682 million to prevent a single instance of cancer.

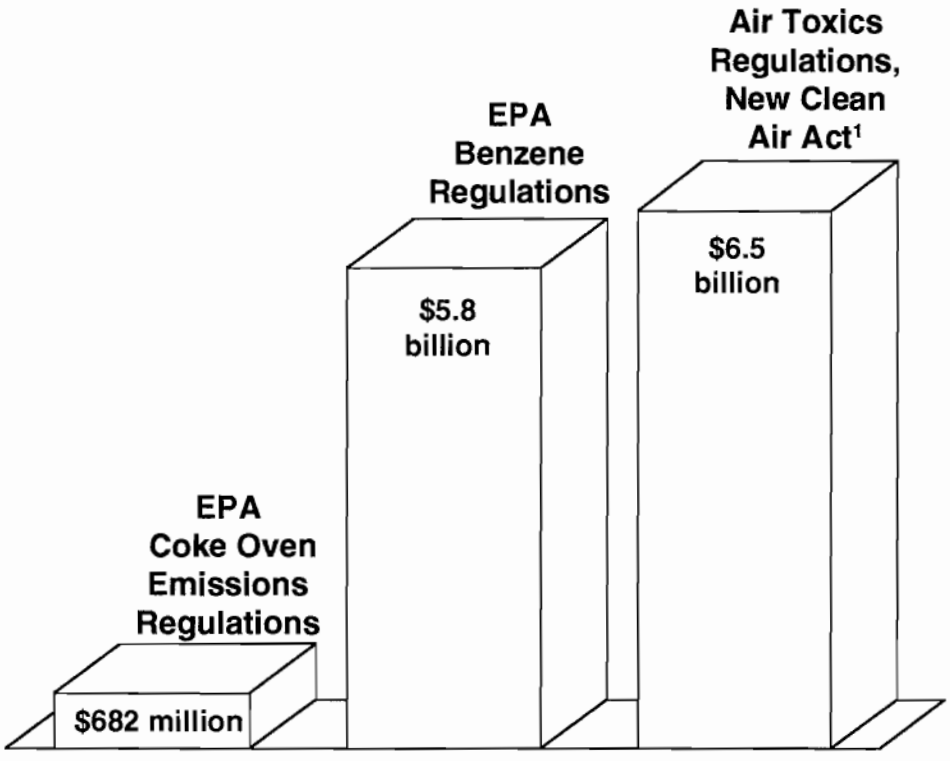
The EPA's cost-is-no-object approach is also reflected in its new benzene regulations, which impose a cost of $200 million a year to prevent an EPA-estimated 3.4 cases of cancer:[41]

- By the EPA's calculations, its new benzene regulations will cost $59 million to prevent a single instance of cancer.
- By more realistic calculations, the cost of each cancer prevented will be $5.8 billion.

"Outdoor air regulations require industry to spend $6.5 billion per hypothetical life saved."

FIGURE II

The Cost of Preventing a Single Cancer



[1]Midpoint of the estimates

Source: Task Force Report, "Progressive Environmentalism," National Center for Policy Analysis, NCPA Policy Report No. 99, April 1991, p. 45.

Applying this more realistic standard to all air toxins, it appears that the Clean Air Act's new regulations may prevent three to five cancers per year rather than the 350 to 500 estimated by the EPA. The cost per cancer prevented will be between $4 billion and $9 billion per year. [See Figure II.]

"The EPA has shown a willingness to spend the entire GNP to save one hypothetical life."

The National Cancer Institute's goal is to reduce the nation's 470,000 annual cancer deaths by one-half by the year 2000. The institute does not even mention reducing carcinogenic chemicals in the environment as one of its objectives. However, as suggested by the EPA's own science advisory panel, using resources efficiently is not necessarily an agency goal.

Case Study: The Worst Regulations. The cost-benefit ratios shown in Figure II are by no means the worst examples of regulatory costs. Both OSHA and the EPA have imposed other regulations that cost billions of dollars per life hypothetically saved. For example:[42]

- A 1987 OSHA limit on occupational exposure to formaldehyde imposes a cost of $86 billion per life saved.
- A 1991 EPA regulation governing atrazine/alachlor in drinking water imposes a cost of $92 billion per life saved.
- And a 1990 EPA regulation governing wood preservatives imposes a cost of $5.7 trillion per life saved — which implies that *the EPA is willing to spend the entire GNP to avoid a single premature death.*

Why Money Matters. Ardent environmentalists contend that environmental goals are worth pursuing regardless of the cost. They are wrong for four reasons.

First, as individuals we are not willing to spend all of our income pursuing any environmental goal. As noted above, most people are willing to live with chemical risks in the air of their own homes because a chemical-free environment is not the only thing they care about. Money spent ridding the environment of pollutants is not available to purchase other goods and services. And just as individuals face trade-offs, so does society. No rational person would want to spend all of society's wealth eliminating a single risk.

Second, even if we believe that health should be pursued at all costs, the regulations described above are indefensible. Millions of dollars spent to save one hypothetical life at some undefined point in the future is money not available for prenatal care or AIDS research. The dollars the EPA requires industry to spend could be spent elsewhere to save many more lives.

Third, even if we believe that broad environmental goals should be pursued at all costs, the regulations described above are indefensible. Millions of dollars spent to achieve a trivial, hypothetical benefit is money not available for other worthwhile environmental aims.

Finally, the regulations described above are self-defeating even on their own terms. The reason? Spending enormous amounts of money on a single risk lowers the take-home pay of workers, and numerous studies have confirmed that higher incomes and better health go hand in hand.[43] When people have more income, they seek more preventive medical care, drive safer cars and reduce countless other risks to health and safety in their daily lives. For example:[44]

"Regulatory spending can cost more lives than it saves."

- One study concluded that every time society spends from $5 million to $12 million in regulatory costs, an additional death is caused because of the lower standard of living that results.

- Based on this analysis, if the EPA requires industry to spend more than $12 million to save a life, it kills more people than it saves.

We discuss the implications of this study for indoor air regulation below.

Options for Government on Indoor Air

For policymakers, the possible responses to indoor air quality problems are: (1) do nothing, (2) provide information, (3) set air quality standards and (4) regulate the sources of specific pollutants. If government intervenes, the best policy is to provide information, leaving the private sector free to act as it sees fit. The worst policy is to try to regulate the sources of specific pollutants.

Option 1: Do Nothing. The strongest argument for doing *nothing* is that if government does *anything*, the cure is likely to be worse than the disease. Could regulators conceivably improve on private sector solutions? Yes. Are they likely to do so? Based on our experience with the regulation of outdoor air, no.

The second strongest argument for a do-nothing policy is that most of the private sector is responding responsibly as more information becomes available about real risks. A sensible cost-benefit approach toward indoor air quality is more likely if the matter is left in private hands.

In general, the private sector is much better able to solve indoor than outdoor air problems. Outdoors, there are thousands of polluters and thousands of victims. The costs of polluting more are mainly imposed on others, and the benefits of polluting less are mainly enjoyed by others. Indoors, things are different. Although the initial effects of poor air quality are felt by building

inhabitants, ultimately the bulk of the cost is borne by building owners — as tenants leave, file lawsuits or pay less rent. Building owners, therefore, tend to bear the cost of their failure to maintain high air quality and reap the benefits of their efforts to improve things.

Option 2: Provide Information. A serious problem with indoor air pollution is that it often goes unrecognized by those at risk. Thus government may have a role in providing information on the existence of a potential problem.

A government agency might, for example, determine the level of air quality in buildings and post this information with some explanation of its significance. Such a policy would inform customers, workers, proprietors and employers. As people responded to the information, building owners also would respond. In some cases, the response would lead to significant improvements in indoor air quality. In other cases, the improvements might be minor.[45]

"Instead of regulations, why not give people information and let them make their own choices?"

Is there a practical way to provide such information? A multipage document listing the concentration of hundreds of chemicals along with other technical information would be worthless to most people. However, the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) already has developed a ventilation standard for buildings.[46] The standard could serve as a norm in the following way: People would ordinarily assume that a building met the ASHRAE standard and was periodically checked for dangerous containments. Owners of buildings that failed to meet the standard would be required to post warnings listing the ways in which the building deviated.

A policy of posting information on indoor air quality and letting those with the most at stake respond as they see fit is similar to the current policy of local public health departments that inspect restaurants and post sanitation ratings in each. When information on cleanliness is available to customers, restaurant owners have a strong incentive to keep their establishments clean. Building owners would have similar incentives.

Why would people want to enter or work in a building with substandard air quality? One reason is that there is not one "best" air quality in all buildings. As noted above, in some cases it is profitable for building owners to improve air quality. But in other cases higher air quality comes with a price tag.

As discussed below, when higher air quality involves significant cost, that cost is likely to be borne by workers in the form of lower wages.

Clearly, there are differences among workers in their willingness to trade take-home pay for clean air. But even if all workers had the same preferences, the cost of clean air varies radically from workplace to workplace. Thus the same willingness to trade money for clean air would result in quality differences from building to building.

There are also likely to be differences among the preferences of customers of different buildings. For example, those who are enjoying an evening in a local bar or pool hall may be less concerned with high indoor air quality standards than are those who are recovering from illness in a hospital. Also, people patronizing an establishment are usually interested in a package of attributes, of which air quality is only one. People choosing between restaurants may go to the one with better food or more appealing decor, even though they know it has lower air quality. There is no one best level of indoor air quality for all situations.

Even if there *were* a best level, it would be extremely difficult for the EPA or any other bureaucratic organization to discover it. And it is completely impossible for any government agency to determine the appropriate air quality in each of the millions of U.S. businesses. Decisions on air quality are best made by those who have to compete for workers and customers, *assuming those individuals have information on the air quality in different establishments.*

"Instead of a command-and-control approach, why not set standards and give industry the freedom to meet them?"

Option 3: Setting Air Quality Standards. More aggressive than providing information would be to mandate an acceptable level of indoor air quality, allowing owners and managers of individual buildings to choose their method of reaching that level.

For example, the federal government might adopt the ASHRAE standard for ventilation and require that all buildings meet it. This would deny people the right to make their own choices about the level of air quality, but it would allow the private sector to find the least expensive ways of achieving the standard.

When an indoor air pollution problem is identified, the least-cost response will vary. In some cases, the best solution may be to simply open some windows or bring in a couple of Boston ferns. Some problems can best be solved by moving certain tasks to a more remote or better ventilated part of the building or by contracting the task to a firm that can perform it more safely. In other cases, the best solution may be to reassign an environmentally sensitive employee to another work area. In extreme situations, say in

the case of a particularly serious health hazard, the best action may be to demolish an existing building and build a new one.

Option 4: Regulating the Sources of Pollution. If government were to regulate indoor air the way it regulates outdoor air, it would single out particular sources of pollutants and try to regulate those sources in specific ways. This approach would be a mistake for several reasons.

First, a command-and-control approach is inevitably more costly. As Table II shows, when government tells the private sector how to control pollution, the method it imposes is almost always far more expensive than allowing people to experiment and to adopt the least costly method.

Second, attempting to improve indoor air by regulating individual sources of pollutants does not guarantee improvement unless *every* source is regulated. As Figure III shows, a contaminant may come from many different sources, and frequently the source is not known. In any event, attempting to regulate the tens of thousands of potential sources of pollutants is probably impossible.

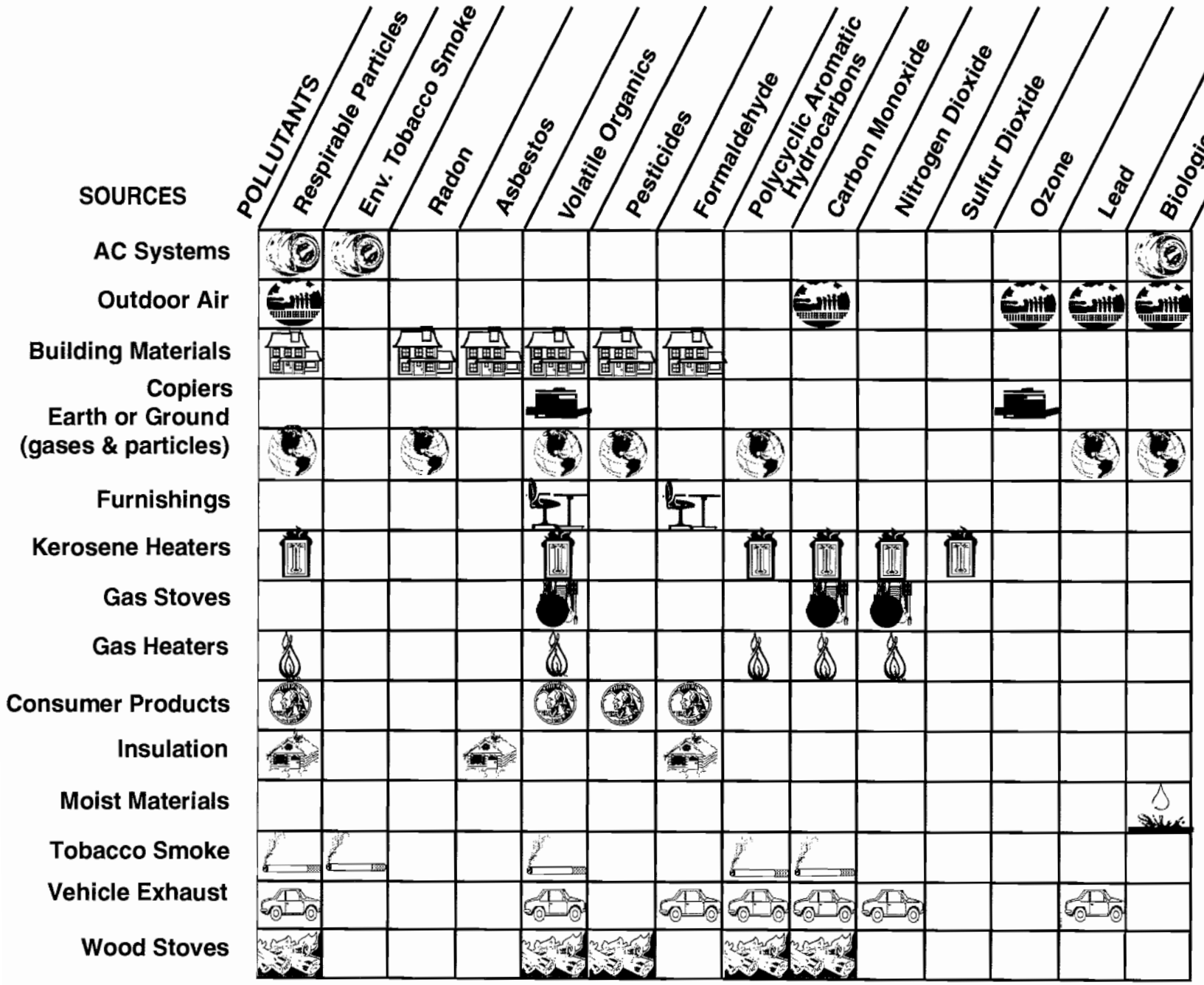
"Instead of regulating each individual source of a pollutant, why not simply clean up the air?"

Hundreds of potentially harmful pollutants can be found indoors, most of them are not readily noticed and, when they are, the symptoms they produce are not always traceable to a specific pollutant. [See Figure III.] Indoor pollutants, particularly in offices, may be generated by building materials, furniture, carpeting, office equipment, cleaning compounds, human metabolism and outdoor air. In addition to these organic compounds are the host of common fibers, dusts and microbes that can cause adverse physical reactions. Furthermore, most of these pollutants cause similar symptoms.[47] For example, it is impossible to differentiate the symptoms caused by formaldehyde from adhesives, ammonia from microfiche machines, oxides of nitrogen from combustion processes, ozone from laser printers and volatile organic chemicals from carpets.[48]

Rather than regulating each source of each pollutant, a better approach may be to remove whole categories of pollutants from the air.

Finally, allowing an agency such as the EPA to regulate individual sources of indoor pollutants undoubtedly would create many of the same problems caused by EPA regulation of outdoor pollution sources. These include the practice of requiring the private sector to bear billions of dollars of costs in order to achieve trivial benefits.

FIGURE III



Source: Dennis F. Naugle and Terrence K. Pierson, "A Framework for Risk Characterization of Environmental Pollutants," *Journal of Air and Waste Management Association,* Vol. 41, No. 10, Oct. 1991, Fig. 1, p. 1299.

The Costs of Indoor Air Regulation

No one can know in advance what indoor air regulation might cost. But if government regulated indoor air as aggressively as it is beginning to regulate outdoor air, the cost to the private sector easily could be $100 billion or more. Although this cost would be imposed directly on business, workers would lose income, jobs and even their lives.

Lower Take-Home Pay. The effect of indoor air regulation costs would be similar to a tax on labor. Since the purpose of the regulations would be to protect employees, the more employees there are, the higher the cost.[49] Roughly speaking:

- If the private sector were required to spend $10 billion to improve indoor air, that would be equivalent to a $90 tax on every employee.
- A $100 billion regulatory cost would be equivalent to a $900 tax on each employee.

"The cost of indoor air regulations would ultimately be borne by employees."

Who would pay this increased cost? Almost certainly, the workers themselves. In competitive labor markets, the cost of employing an additional worker tends to equal the value that worker produces. If worker productivity remains the same, the company must lower wages to pay clean air costs.

Many proponents of aggressive regulation assume that the costs will somehow be borne by "business." However, business is a relationship — between workers, managers, consumers, stockholders. Although government frequently taxes relationships, relationships don't pay taxes — people do. Ultimately, all taxes are paid by individuals. And, employees are the individuals most likely to bear the full costs of indoor air regulation.[50]

Regressive Taxes. The cost of indoor air regulation would be imposed on workers like a regressive tax. The lower the employee's income, the higher the burden as a percent of income. [See Figure IV.] For example:

- At $900 per employee, the cost of clean air would be almost 10 percent of the annual income of a minimum-wageworker.
- By contrast, the cost would be less than 1 percent of the income of a $100,000-a-year employee.

Lost Jobs. An important economic principle is that when something is taxed, people use less of it. Because the costs of indoor air regulation are effectively a tax on labor, such regulation would almost certainly lead to fewer jobs and more unemployment. Figure V shows the number of jobs that likely would be eliminated. As the figure shows:[51]

- If regulatory costs were $40 billion, about 360,000 jobs would be lost.
- An $80 billion regulatory burden would eliminate about 720,000 jobs.

Loss of Life. As noted above, studies show that regulations can cost more lives than they save if they substantially reduce worker incomes. Although we do not fully understand the causal mechanism, studies within and among different countries conclude that higher incomes lead to longer life expectancies and vice versa.[52] Take automobile accidents, for example. In the United States there is a strong negative relationship between income and automobile accidents. Presumably, higher income families can afford to change their tires more often, maintain their cars better and purchase safer cars to begin with.

"According to the National Cancer Institute, poverty is one of the most important causes of cancer."

The incidence of cancer is another example. A primary goal of many proponents of indoor air regulation is to reduce the level of airborne carcinogens and, therefore, the risk of cancer. But if regulation reduces employee income, the exercise could be self-defeating. According to the National Cancer Institute, poverty is one of the most important causes of cancer.[53] For example:[54]

- The incidence of cancer is 6 percent to 10 percent higher among blacks than among whites.
- But at the same income and educational level, blacks may have a lower incidence of cancer than whites.

Table IV shows the results of these and other links between mortality and low income. As the table shows:

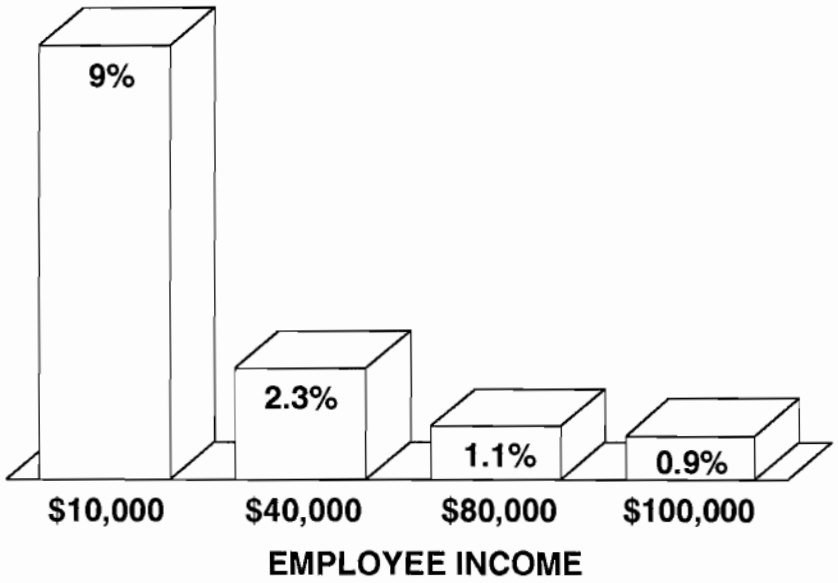
- A white male earning the minimum wage has a 78 percent higher probability of dying in any given year than one with an income of $50,000.
- A white female has a 43 percent higher probability of dying if she is earning the minimum wage rather than $50,000.

Another research finding is that this relationship begins to vanish among those with above-average incomes. Taking $1,000 away from people who earn $80,000 a year probably has no effect on mortality. Taking $1,000 away from everyone who earns $20,000 a year could have a noticeable effect. SEC regulations directed at high-paid Wall Street stockbrokers probably cause no loss of life. Indoor air regulations that burden lower paid employees could lead to substantial loss of life.

"A $100 billion regulatory burden would mean $900 less take-home pay for every employee."

FIGURE IV

Cost of $100 Billion of Indoor Air Regulation As a Percent of Employee Income[1]

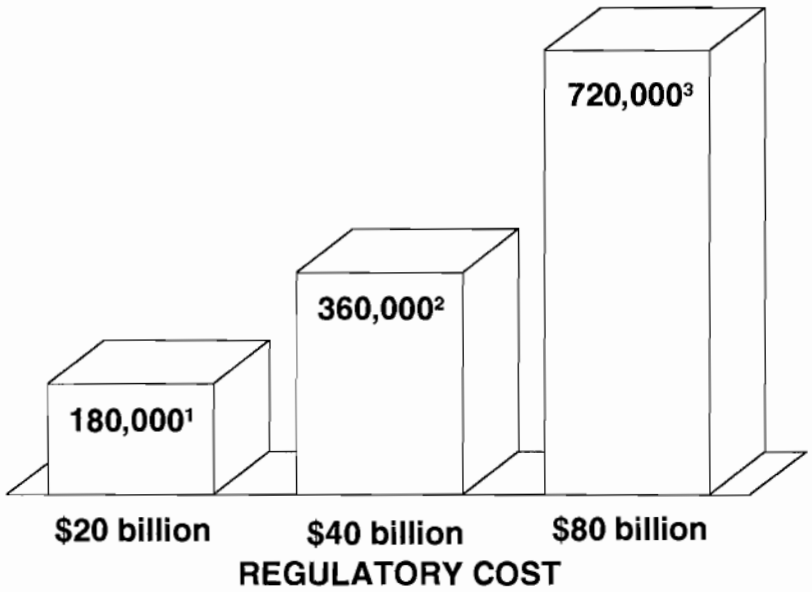


[1]Assumes equal cost per employee.

"Job losses would be more likely among lower paid employees."

FIGURE V

Potential Job Losses as a Result of Indoor Air Regulation



[1]Assumes workers receive $2.5 billion in benefits.

[2]Assumes workers receive $5 billion in benefits.

[3]Assumes workers receive $10 billion in benefits.

Source: Estimate based on Fiscal Associates tax model.

"Studies show that lower take-home pay leads to higher mortality."

TABLE IV

Mortality Rates[1]

(Deaths per 1,000 population per year)

Income (1991)	White Males	White Females
Under $9,174	**13.5**	**6.7**
$9,175 - $18,348	**10.9**	**6.2**
$18,349 - $27,522	**9.0**	**5.5**
$27,523 - $36,696	**7.8**	**5.3**
$36,697 - $45,870	**8.4**	**5.1**
$45,871 or more	**7.6**	**4.7**

[1]Age adjusted for persons age 25 to 64.

Source: E. M. Kitagawa and P. M. Hansen, *Differential Mortality in the United States of America: A Study in Socioeconomic Epidemiology* (Cambridge, MA: Harvard University Press, 1973). Updated in Ralph L. Keeney, "Mortality Risks Induced by Economic Expenditures," *Risk Analysis*, Vol. 10, No. 1, 1990, Table IV, p. 153.

Figure VIA shows the likely increase in mortality as a result of potential indoor air regulatory burdens. As the figure shows:

- Each $1 billion of regulatory costs is likely to lead to 193 additional deaths.
- To justify, say, $20 billion in regulatory costs, the regulations must be shown to save more than 3,855 lives — since that is the number of deaths likely to be caused by the regulations.

Figure VIA assumes that the costs of regulation would be spread evenly over all the workers in the country. If the burden fell disproportionately on lower income employees, the death rate would be higher. Even if the costs were spread evenly, the effects on mortality would not be even. As Figure VIB shows:

- With $10 billion in regulatory costs, a male earning close to the minimum wage would have an increased probability of dying that is 10 times the increase for a male earning $33,000 and 218 times the increase for one earning $66,000.

- A female earning close to the minimum wage would have an increased probability of dying that is more than five times greater than a female earning $33,000 and 46 times greater than one earning $66,000.

Effects on the Real Estate Industry. The real estate industry is already depressed — a result of the 1986 Tax Reform Act,[55] the collapse of the S&L industry and problems in commercial banking. Indoor air regulation threatens to make conditions worse. In fact, indoor air regulation has the potential to harm the real estate industry more than the other three factors combined.

The Politics of Indoor Air

If the EPA assumes greater control over the regulation of indoor air quality, it will almost surely adopt a policy of detailed commands and controls rather than a far more efficient, effective policy that relies on market incentives. This pessimistic assessment is based on the EPA's: (1) policy initiatives regarding outdoor air pollution, (2) recent statements on indoor air quality issues and (3) internal and external political pressures. Even if the EPA does not gain control, it is likely that some other agency will apply EPA-type regulations.

"Smoking is a problem in only 2 percent of buildings."

Agency Turf Battles. The EPA is trying to extend its regulatory authority over indoor air pollution (Senate Bill S455 is a product of this effort), which is now the primary responsibility of OSHA. Such attempts on the part of federal agencies to expand their authority are common and stem from their desire for increased budgets. OSHA is responding with more aggressive regulations of its own.

The Antismoking Lobby. To gain political support for more control over indoor air, the EPA has found it convenient to single out tobacco smoke as the major source of indoor pollution.[56] Yet the antismoking concern is misdirected. When it is being candid, the EPA recognizes that indoor air pollution is best addressed as a broad problem.[57] And even if it did make sense to focus attention on particular pollutants, tobacco smoke would be a low priority.[58]

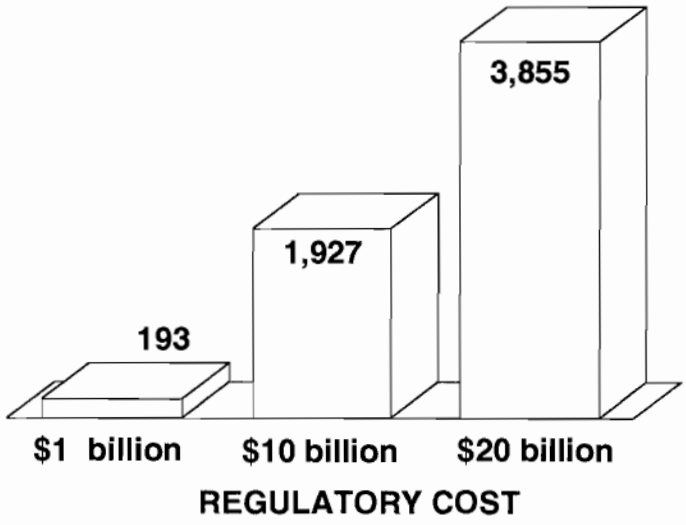
- As noted above, the National Institute for Occupational Safety and Health found that tobacco smoke was a problem in only 2 percent of the buildings it examined.[59]

- In a study of 412 sick buildings over the period 1980-88, Healthy Buildings International found that tobacco smoke was the primary pollutant in only 3 percent.[60]

"Every $1 billion of regulation is likely to cost 193 lives."

FIGURE VIA

Potential Additional Deaths Per Year Due to Regulation of Indoor Air[1]

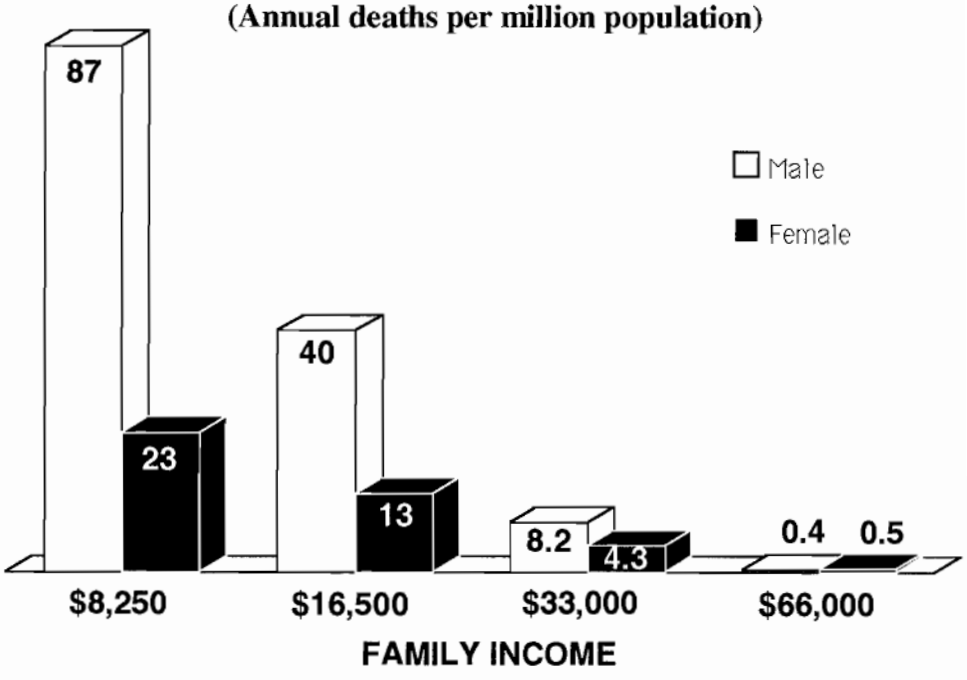


"The risk would be greatest for the lowest paid employees."

FIGURE VIB

Potential Deaths Caused by $10 Billion of Indoor Air Regulatory Costs[1]

(Annual deaths per million population)



[1]Assumes equal cost per employee; 1991 dollars.

Source: Based on Kitagawa and Hauser mortality rates, analyzed in Ralph L. Keeney, "Mortality Risks Induced by Economic Expenditures," *Risk Analysis*, Vol. 10, No. 1, 1990, Table VI, p. 154.

- Other categories, some of which include large numbers of individual pollutants, are far more significant sources of indoor pollution than tobacco smoke. [See Table II.]

Tobacco smoke is politically sensitive because it is readily noticed and is commonly blamed for indoor air pollution problems it has little if anything to do with.[61] Antismoking groups are exploiting the visibility of tobacco smoke and the legitimate concerns over indoor air quality to push policies that do more to punish smokers than to improve the quality of indoor air.

Conclusion

"Best policy: Let the private sector continue to find cost-effective solutions."

Spurred by market incentives, the private sector is solving the problems of indoor air pollution. Because in most cases the problems are caused by poor ventilation, many building managers are finding that improved ventilation pays for itself — through increased worker productivity and reduced risk of lawsuits. Market incentives have also induced inventors to devise new, cost-effective ways of improving air quality, including the use of ordinary house plants to remove toxins from the air.

A reasonable public policy is to encourage the private sector to continue seeking cost-effective solutions. For if we allow government to regulate indoor air the way it regulates outdoor air, the results would be devastating to the real estate industry and to workers in many industries — workers who would suffer from income reductions, lost job opportunities and even higher mortality rates.

Footnotes

[1] See the discussion in T. Sterling and S. Kleven, "The Epidemiology of 'Sick Public Buildings'," in *Indoor Air Quality Symposium,* National Academy of Science of Buenos Aires, San Carlos de Bariloche, Argentina, December 6-7, 1988, pp. 79-107; and E. Sterling, "Building Architecture and Building Air Quality," in *Indoor Air Quality Symposium*, pp. 109-18.

[2]For a general review of the literature on methylene chloride, see U.S. Environmental Protection Agency, *Health Assessment Document for Dichloromethane* (methylene chloride), Final Report, February 1985. EPA/600/8-82/004F; U.S. Environmental Protection Agency, "Initiation of Regulatory Investigation for Methylene Chloride," Federal Register 201 (1985), pp. 42037-47; U.S. Consumer Product Safety Commission, "Household Products Containing Methylene Chloride: Status as Hazardous Substances," Federal Register 51 (161) (1986), pp. 29778-809.

[3] Bruce N. Ames, Renae Magae, Lois Swirsky Gold, "Ranking Possible Carcinogenic Hazards," *Science*, Vol. 236, April 17, 197, pp. 271-280.

[4] See National Research Council (NRC), Committee on Indoor Pollutants, *Indoor Pollutants* (Washington, DC: National Academy Press, 1981), p. 20. See also W. Wade, W. A. Cote and J. E. Yocom, "A Study of Indoor Air Quality," *Journal of the Air Pollution Control Association*, Vol. 25, No. 9, 1975, pp. 933-39; and J. Yocom, "Indoor-Outdoor Air Quality Relationships," *Journal of the Air Pollution Control Association*, Vol. 32, No. 5, 1982, pp. 500-520.

[5] This 1988 EPA study is discussed by Gray Robertson, "The Role of Ventilation in Controlling Indoor Air Quality," manuscript, ACVA Atlantic Inc. (now Healthy Buildings International, Inc.), Fairfax, VA, 1988.

[6] See Richard L. Stroup and John C. Goodman, "Making the World Less Safe: The Unhealthy Trend in Health, Safety and Environmental Regulation," National Center for Policy Analysis, NCPA Policy Report No. 137, April 1987.

[7] Ibid.

[8] See J. M. Barbaree, Controlling Legionella in Cooling Towers: Factors Affecting the Transmission of Legionella from Aerosol-Emitting Equipment to People Are Described," *ASHRAE Journal*, June 1991, pp. 34-42; M. O'Mahony, A. Lakhani, A. Stephens, J. G. Wallace, E. R. Youngs and D. Harper, "Legionnaires' Disease and the Sick-Building Syndrome," *Epidemic Information*, Vol. 103, 1989, pp. 285-92; E. J. Bardana, Jr., A. Montanaro and M. T. O'Hollaren, "Building-Related Illness: A Review of Available Scientific Data," *Clinical Reviews in Allergy,* Vol. 6, 1988, pp. 61-89; and H. A. Burge and M. Hodgson, "Health Risks of Indoor Pollutants," *ASHRAE Journal*, Vol. 30, 1982, pp. 34-35, 38.

[9] U.S. Environmental Protection Agency, *The Inside Story: A Guide to Indoor Air Quality* (Washington: EPA, September, 1988), p. 27

[10] Robert Axlerad, "Economic Implications of Indoor Air Quality and Its Regulation and Control," in *NATO/CCMS Pilot Study on Indoor Air Quality: The Implications of Indoor Air Quality for Modern Society,* Report on meeting in Erice, Italy, February 1989, pp. 89-116.

[11] See Sterling and Kleven, "The Epidemiology of 'Sick Public Buildings' "; and Sterling, "Building Architecture and Building Air Quality."

[12] "EPA Implicated in SBS Lawsuit," *Air Conditioning, Heating and Refrigeration News*, November 4, 1991.

[13] Charles Hardy, "Indoor Pollution Targeted by Feds," *San Francisco Examiner,* October 6, 1991; and Charles Hardy, "Victim's Family Seeks Damages," *San Francisco Examiner*, September 25, 1991.

[14] Ralph Wakley, "Only One Case of Disease Confirmed," (Ogden, UT) *Standard - Examiner*, October 27, 1991.

[15] Art Charlton, "Pollution Agency Ponders Building," (Newark) *Star Ledger*, October 17, 1991.

[16] P. Binnie, "The Role of Ventilation in Controlling the Quality of Indoor Air, Including ETS," in A. Armitage, ed., *Other People's Tobacco Smoke* (East Yorkshire, U.K.: Galen Press, 1991), pp. 159-72.

[17] See James E. Woods, "Cost Avoidance and Productivity in Owning and Operating Buildings," *Occupational Medicine*, Vol. 4, No. 4, Oct.-Dec. 1989, p. 760.

[18] See "Outside Counsel," *New York Law Journal*, September 10, 1991.

[19] J. Melius et al., "Indoor Air Quality — The NIOSH Experience," *Ann Am Conf Gov Ind Hyg*, Vol. 10, 1984, pp. 3-7; G. Robertson, "Source, Nature and Symptomology on Indoor Air Pollutants," in R. Perry and P. Kirk, eds., *Indoor and Ambient Air Quality* (London: Selper Ltd., 1988), pp. 311-19; J. Kirkbride, *Sick Building Syndrome: Causes and Effects* (Ottawa, Canada: Health and Welfare Canada, October 24, 1985); C. Collett et al., "A Database of Problem Buildings: Learning by Past

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[20] E. J. Bardana, Jr., A. Montanaro and M. T. O'Hollaren, "Building-Related Illness," Table 4, p.78.

[21] Testimony of Paul A. Cammer, Business Council on Indoor Air, before the Subcommittee on Health and Safety of the Committee on Education and Labor, U.S. House of Representatives, July 1991, p. 2.

[22] General Accounting Office (GAO) Report to the Chairman, Subcommittee on Superfund, Ocean and Water Protection, Committee on Environment and Public Works, U.S. Senate, *Indoor Air Pollution: Federal Efforts Are Not Effectively Addressing a Growing Problem,* October 1991, p. 22.

[23] From 5 cubic feet of outside air per minute per person (cfm/person) to 20 cfm/person. Five cfm/person was the pre-1989 ventilation standard of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and 20 cfm/person is its current standard.

[24] See Joseph H. Eto and Cecile Meyer, "The HVAC Costs of Fresh Air Ventilation," *ASHRAE Journal,* September 1988, pp. 31-35. See also J. Ventesca, "Operation and Maintenance for Indoor Air Quality: Implications from Energy Simulations of Increased Ventilation," in *IAQ 91: Healthy Buildings* (ASHRAE Publications, 1991), pp. 375-78; and A. Willman, "Looking at the Relationship Between IAQ and Energy Costs," *Indoor Air Review*, Vol. 10, No. 12, November 1991.

[25] Steve LaRue, "Scientist Plants Idea of Desktop Air Cleaners," *San Diego Union*, November 18, 1991.

[26] Stephen Strauss, "Plants May Cure Sick Buildings," (Toronto) *Globe and Mail*, November 1, 1991.

[27] U.S. Environmental Protection Agency, *Environmental Investments: The Cost of a Clean Environment*, February 1991. Cited in *Inside EPA*, February 8, 1991, p.1.

[28] U.S. Environmental Protection Agency, *Unfinished Business: A Comparative Assessment of Environmental Problems, 1987.*

[29] K. Landy, Marc J. Roberts and Stephen R. Thomas, *The Environmental Protection Agency: Asking the Wrong Questions* (New York: Oxford University Press, 1990).

[30] The broad outlines of EPA policy are determined by Congress, but the EPA has significant influence on pollution control legislation and can exercise significant discretion within the boundaries established by that legislation.

[31] When the EPA attempted to reduce emissions of sulfur oxides by loosening the stack scrubber standards, the agency was immediately sued by environmental organizations for failing to properly enforce government regulations. See Robert Crandall, "Why is the Cost of Environmental Regulation So High?", Policy Study 110, Center for the Study of American Business, Washington University, St. Louis, MO, February 1992. The 1990 Clean Air Act amendments ostensibly encourage a market for the right to pollute, giving electric utilities greater flexibility in how they meet federal standards. Unfortunately, the legislation contains exemptions, restrictions and promised subsidies that favor the continued use of high sulfur coal and stack scrubbers. See James L. Johnston, "A Market Without Rights: Sulfur Dioxide Emissions Trading," *Regulation*, Fall 1991, pp. 24-29.

[32] These studies considered air pollution control costs in different industries, in different locations, with different pollutants.

[33] Expert panel on the role of science at the EPA, *Safeguarding the Future: Credible Science, Credible Decisions* (Washington, DC: Environmental Protection Agency, March 1992).

[34] *EPA Watch*, Vol. 1, No. 3, March 31, 1992.

[35] See Frederick Rueter and Wilbur Steger, "Air Toxics and Public Health," *Regulation Magazine*, Cato Institute, Winter 1990; and Lester Lave, *How Safe Is Safe Enough? Setting Safety Goals*, 1990, Center for the Study of American Business, Washington University, St. Louis, MO.

[36] Reported by Warren Brookes, personal communication.

[37] A study by Oxford professors Richard Doll and Richard Peto, commissioned by the Office of Technology Assessment, examined U.S. national cancer mortality records from 1933 to 1978 and found that only approximately 2 percent of all cancers are caused by environmental contamination or pollution. See Doll and Peto, "The Causes of Cancer: Quantitative Estimates of Avoidable Risks of Cancer in the United States Today," *Journal of the National Cancer Institute*, Vol. 66, No. 6, 1191-1308, June, 1981. The EPA's own findings via toxicological risk assessment corroborate Doll and Peto's analysis. According to the EPA, only between 1 and 3 percent of all cancers are caused by "pollution." See EPA, *Unfinished Business.* The EPA figures were extrapolated in Michael Gough, "Estimating Cancer Mortality," *Environmental Science & Technology,* August 1989, p. 925.

[38] Rueter and Steger, "Air Toxics and Public Health."

[39] "Air Toxic Madness," *Executive Alert*, Vol. 4, No. 3, May/June 1990, p. 5.

[40] Rueter and Steger, "Air Toxics and Public Health."

[41] Ibid.

[42] Source: John F. Morrall, III, "A Review of the Record," *Regulation*, Vol. 10, No. 2, 1986, p. 30. Updated in Richard B. Belzer, "Regulating Risk: An OMB Perspective." Paper presented to National Safety Council Conference on "Regulating Risk: The Science and Politics of Risk," June 24, 1991.

[43] See Aaron Wildavsky, *Searching for Safety* (New Brunswick, N.J.: Transaction Publishers, 1988), Ch. 3.

[44] Ralph L. Keeney, "Mortality Risks Induced by Economic Expenditures," *Risk Analysis*, Vol. 10, No. 1, 1990, pp. 147-59. Numbers in the text are updated to reflect 1991 prices.

[45] The motivation to respond appropriately to the demand for indoor air quality from an informed public is obviously stronger in the case of privately owned buildings and businesses than in the case of government buildings. In the former case, it is more likely that the person in the best position to respond will lose income if he or she does not. While it may be reasonable for government to impose specific air quality standards in its own buildings, it may be unreasonable for them to do so in privately owned buildings.

[46] ANSI/ASHRAE Standard 62-189 (1990).

[47] See W. R. Solomon, "Airborne Microbial Allergens: Impact and Risk Assessment," *Toxocology and Industrial Health,* Vol. 6, 1990, pp. 309-24; M. J. Finnegan and C. A. C. Pickering, "Review: Building Related Illness, *Clinical Allergy*, Vol. 16, 1986, pp. 389-495; R. Rylander, S. Sorenson, H. Goto, K. Yuasa and A. Tanaka, "The Importance of Endotoxin and Glucan for Symptoms in Sick Buildings," in C. J. Bieva, Y. Courtois and M. Govaerts, eds., *Present and Future of Indoor Air Quality* (Amsterdam: Elsevier, 1989), pp. 219-26; and A. Gravesen, L. Larsen, F. Gyntelberg and P. Skov, "Demonstration of Microorganisms and Dust in Schools and Offices: An Observational Study of Non-Industrial Buildings," *Allergy*, Vol. 41, 1986, pp. 520-25.

[48] See Robertson, "The Role of Ventilation in Controlling Indoor Air Quality."

[49] In this section, the cost of indoor air regulation is treated as equivalent to a head tax — one which falls equally on all employees. This assumption may not be precisely correct. For example, higher paid employees may have larger offices and therefore the cost of clean air may rise somewhat with employee income. On the other hand, the air space in which lower income employees work may be more polluted and more costly to clean up. In general, however, the cost to an employer will rise proportionately with the amount of space, and the amount of space will tend to increase proportionately with the number of employees — regardless of the salaries of those employees. The cost of clean air, therefore, is probably more related to the number of employees than it is to employee income.

[50] In this respect, a mandated clean air requirement is similar to a mandated fringe benefit such as health insurance or day care. The mandate is imposed on the employer, but the cost of the mandate is financed by lower take-home pay.

[51] Calculations made by Aldona Robbins and Gary Robbins, Fiscal Associates.

[52] See the review of the literature in Keeney, "Mortality Risks Induced by Economic Expenditures."

[53] See Ann Gibbon, "Does War on Cancer Equal War on Poverty?", *Science,* Vol. 253, No. 5017, 1991, p. 260.

[54] *Journal of the National Cancer Institute,* Vol. 83, No. 8, April 17, 1991.

[55] Among other changes, the Tax Reform Act of 1986 increased the maximum capital gains tax rate by 40 percent, lengthened depreciation schedules by a third and imposed severe "passive loss" restrictions on investors.

[56] See Albert Karr and Rose Gutfield, "OSHA Inches Toward Limiting Smoking," *Wall Street Journal*, January 16, 1992, p. B1.

[57] For example, in its 1989 Report to Congress, the EPA stated that "more can be done to reduce overall exposures and risks by altering building designs and ventilation patterns than by approaching the problem source-by-source or pollutant-by-pollutant." Environmental Protection Agency, *Report to Congress on Indoor Air Quality*, Vol. III, *Indoor Air Research Needs*, p. 3.

[58] C. J. Proctor, N.D. Warren, M. A. J. Bevan, "Measurements of Environmental Tobacco Smoke in an Air-conditioned Office Building," *Environmental Technology Letters*, Vol. 10, 1989, pp. 1003-18; B. D. Cox and M. J. Whichelow, "Carbon Monoxide Levels in the Breath of Smokers and Nonsmokers: Effect of Domestic Heating Systems," *Journal of Epidemiology and Community Health*, Vol. 39, 1985, pp. 75-78; B. W. Good et al., "Effect of Cigarette Smoking on Residential No. 2 Levels, " *Environment International*, Vol. 8, 1982, pp. 167-75; T. Godish, "Formaldehyde Exposures from Tobacco Smoke: A Review," *American Journal of Public Health*, Vol. 79. No. 8, 1989, pp. 1044-45; J. F. Pedelty and L. C. Holcomb, "A Computer Simulation of Indoor Air Quality Which Models Changes in Point Sources and Ventilation," *Environmental Technology*, Vol. 11, 1990, pp. 1053-62; M. D. Lebowitz et al., "Respiratory Symptoms and Peak Flow Associated with Indoor and Outdoor Air Pollutants in the Southwest," *Journal of the Air Pollution Control Association*, Vol. 35, No. 11, 1985, pp. 1154-58; M. D. Lebowitz, "The Effects of Environmental Tobacco Smoke Exposure and Gas Stoves on Daily Peak Flow Rates in Asthmatic and Non-asthmatic Families," in R. Rylander, Y. Peterson and M. C. Snella, eds., *ETS-Environmental Tobacco Smoke: Report from a Workshop on Effects and Exposure Levels*, University of Geneva, Switzerland, March 15-17, 1983, pp. 90-97; G. Stehlik et al., "Concentration of Dimethylnitrosamine in the Air of Smoke-filled Rooms," *Ecotoxicology and Environmental Safety*, Vol. 6, 1982, pp. 495-500; F. Adlkofer et al., "Significance of Exposure to Benzene and Other Toxic Compounds through Environmental Tobacco Smoke," *Journal of Cancer Research and Clinical Oncology*, Vol. 116, 1990, pp. 591-98; T. Godish, "Residential Formaldehyde: Increased Exposure Levels Aggravate Adverse Health Effects," *Journal of Environmental Health*, Vol. 53, No. 3, 1990, pp. 34-35; and C. J. Proctor, "The Analysis of the Contribution of ETS to Indoor Air," in R. Perry and P. Kirk, eds., *Indoor and Ambient Air Quality* (London: Selper Ltd., 1988), pp. 57-66.

[59] See Bardana, Montanaro and O'Hollaren, "Building-Related Illness," p. 78.

[60] See Gray Robertson, "Indoor Pollution: Sources, Effects and Mitigation Strategies," in Donald J. Ecobichon and Joseph M. Wu, eds., *Environmental Tobacco Smoke: Proceedings of the International Symposium at McGill University* (Lexington, MA: Lexington Books, 1990), pp. 333-55.

[61] As observed by Gray Robertson, whose company specializes in maintaining the indoor air quality in commercial buildings, "In reality, environmental tobacco smoke is merely a symptom of an invisible problem, not a cause. Without question, the leading cause of sick buildings is inadequate ventilation. If visible pollutants like smoke accumulate inside a building, so too do pollutants that are invisible." See Robertson, "Indoor Pollution," p. 333.

About the Author

Dwight Lee is the Bernard B. and Eugenia A. Ramsey Professor of Economics and Private Enterprise at the University of Georgia. He has written more than 70 articles published in professional journals, including several written with James Buchanan, the 1986 Nobel Prize winner in economics. He has also published a large number of editorials and articles aimed at the broader audience beyond the academic community. He is the author of *Quicksilver Capital* and six other books.

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